COMPARISON OF THE PROFITABILITY OF AN ARABLE ROTATION, A MONOCULTURE OLIVE SYSTEM AND A SILVOARABLE SYSTEM IN GREECE USING THE FARM-SAFE MODEL

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Abstract

This study focused on the comparison of the profitability of three different production systems: an arable system, an intensive olive production and a silvoarable system which combine the two previous ones. For this, the Farm-SAFE model has been used, it considers many costs and incomes for each production and returns a simulated Net Margin and annual value. The silvoarable system appears to be the most efficient on a 60 year cycle. The olive production is an important source of incomes, but combining it with an arable production permits to cover and lower the investment costs and to vary the productions is safer.

Keywords: silvoarable; olive; arable; profitability; Farm-SAFE; economic modelisation

Introduction

Faced with climate variability and high fertiliser costs, there is increasing interest in developing sustainable agricultural systems in Greece. Pantera et al. (2017) in Molos, Greece has demonstrated that olive production in the area intercropped with nitrogen-fixing chickpeas was similar to where there was no intercrop. This paper compares three potential systems: i) an arable system with a five-year rotation of wheat/chickpeas/barley/grass-clover mixture/lentils, ii) an intensive olive production system with 280 irrigated trees/ha and a iii) silvoarable system with the same crop rotation and 100 olive trees/ha. The profitability of the three systems was determined using the Farm-SAFE economic model (Graves et al. 2011).

Materials and methods

Even if some studies proved some important co-benefits for trees and crops of being grown on the same plot, these benefits have not been much estimated on the economic point. The profitabilities of the three systems (arable/intensive olive/silvoarable combining the 2 first ones) were compared here in terms of the cumulative net margin (CNM), the net present value (NPV) and an equivalent annual value (EAV) for a 60 year simulation cycle. A discount rate of 4% was assumed to derive the NPV and the EAV, which is the discount rate typically assumed by the European Commission (European Commission 2014). There is an annex at the end of the article explaining what mean these economic concepts. The data for the arable and olive grove systems were collected from farmers, and the data for the agroforestry system was calculated on a pro-rata basis. For the agroforestry arable crops, the crop data were multiplied by the crop area of the virtual silvoarable field (85%); and the cost of the agroforestry olive trees was assumed to be related to ratio of the tree density (100/280). The two parameters where the data were assumed not be pro-rata were the olive yields, which were assumed to be 10% higher per tree, due to the lower tree density of trees, and the irrigation cost per tree which was assumed to be 50% lower per tree. The silvoarable yields were calculated for two scenarios: with the default olive and arable yields (Scenario 1) and with 75% of booth of those yields (Scenario 2).

Results

In the initial 13 years of the simulation, the greatest cumulative net margin was obtained from the arable system (as there were no establishment costs for the olive trees) (Figure 1). However after 13 years, the cumulative net margin of the silvoarable system (Scenario 1) was calculated to be greater than the olive-only and the crop-only systems (Figure 1). The silvoarable system with 75% yields (Scenario 2) was calculated to be more profitable than the arable system after 23 years. The olive-tree only system was assumed to have a negative cumulative net margin for the first 33 years due to the high establishment costs and the long time for the trees to produce high yields. The olive tree only system was calculated to become more profitable than the arable system after 41 years and more profitable than the 75% silvoarable system (Scenario 2) after 56 years.

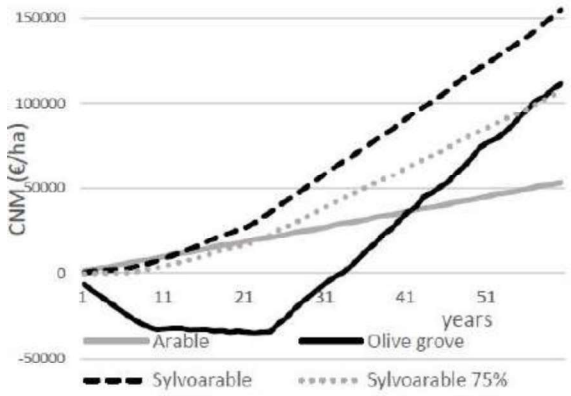

Figure 1: Comparison of simulated cumulative net margin of the arable system, the olive grove system and the silvoarable system with the default yields (Scenario 1), and with 75% of the default yields (Scenario 2).

A sensitivity analysis was used to examine the sensitivity of the cumulative net margin after 60 years. After 60 years, even with no crop production (-100% = 0% of the expected yield), the silvoarable system was calculated to be more profitable than the arable system (Figure 2a). The silvoarable system was also more profitable than the arable system, if the yields were only 25% of those expected (Figure 2a). The cumulative net margin of the silvoarable system after 60 years was more sensitive to changes in the olive yields (Figure 2b). The silvoarable system was more profitable than the arable system if olive yields were at least 25% of the default assumption, and was more profitable than the olive tree-only system if the olive yields were 60% of the expected yields (Figure 2b).

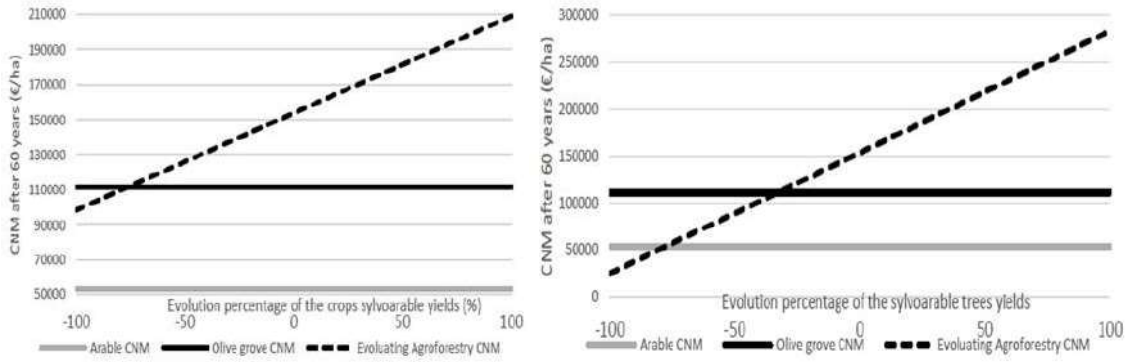

Figure 2: Sensitivity of the cumulative net margin of the arable, silvoarable (Scenario 1), and olive tree only systems after 60 years to a) arable crop yields, and b) olive yields.

The annual net present value (assuming a 4% discount rate) of each project varies during the 60 year simulation (Figure 3). The arable NPV per decade decreased steadily during the simulation. The intensive olive grove starts with a very negative NPV but it increases until the

fourth decade so that it has the highest annual NPV during the three last decades. The mean net present value per decade of the silvoarable system was always positive and also relatively stable increasing up to the third decade before declining. The NPV in the first 10 years is below the arable system because of the high establishment costs of the trees and the very low productivity of the olives during the first seven years until it reaches a maximum at about 30 years.

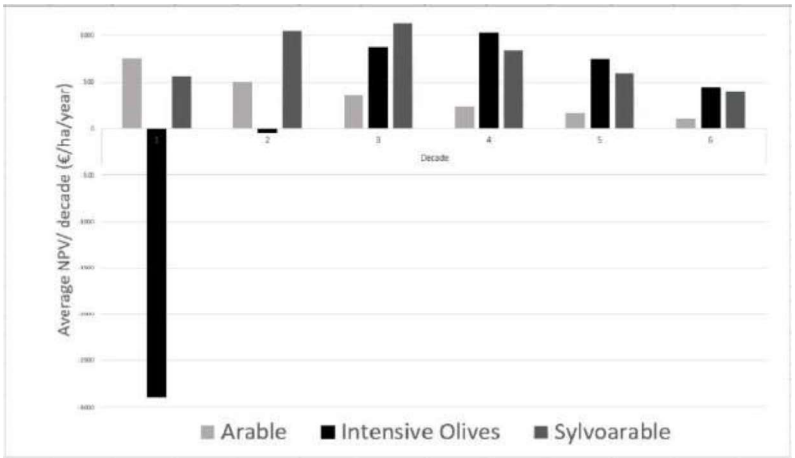

Figure 3: Mean annual net present value (assuming a 4% discount rate) for each decade for the arable, olive tree only and the default silvoarable system (Scenario 1).

The sensitivity of the equivalent annual value (over 60 years and assuming a discount rate of 4%) shows that the silvoarable system was the most profitable system under the default assumptions (Figure 4a) and assuming 75% of the default yields (Figure 4b). The olive tree-only system and the arable systems needed a 50% and a 75% increase in yield respectively to become more profitable than the default silvoarable system (Figure 4a). In Scenario 2, if the silvoarable system yields were only 75% of the default system, both the arable-only and the tree-only became more profitible if the yields of those systems were 35% higher than the expected levels.

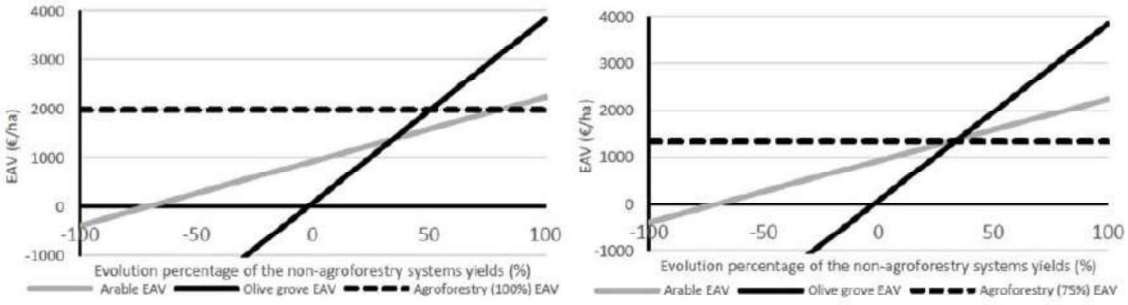

Figure 4: The sensitivity of the equivalent annual value of the arable-only and the olive tree-only to yields relative to the silvoarable system a) (Scenario 1) and b) (Scenario 2).

These results must be looked carefully. Indeed, we can regret that the data (costs & incomes) comes from different sources, which mean different agronomy contexts. Also, most of the machinery costs have not been consider, but the machinery costs of the silvoarable system are surely higher than the other systems. Most of the crops-trees interactions are not consider too, it probably leads to a bias.

Conclusion

It was possible to use the Farm-SAFE model to compare the profitability of an arable-only, an olive tree only, and two silvoarable systems in Greece. The arable rotation was chosen so that

it would theoretically be possible to develop an efficient organic system of production. On the basis of the assumptions made (including a 4% discount rate and a 60 year time-frame), the silvoarable system was more profitable than the arable-only and the tree-only systems.

Annex

Description of the economic concepts:

The cumulative net margin (**CMN**) represents at the end of a year the total amount of the net margin since the beginning of the project.

The net present value (**NPV**) in capital budgeting as an indicator of the profitability of a project, it is calculated by the following formula:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_o$$

Where C_t= net cash inflow during the period t; C_o = total initial investment costs; r = discount rate, and t = number of time periods (Investopedia, s.d.)

The INPV (Infinite Net Present Value) is the NPV if the estimation of what would be the NPV if the project ran forever. Farm-SAFE model has a maximum period of simulation of 60 years, so it is based on a 60 years cycle.

The Equivalent Annual Value (**EAV**) or Equivalent Annual Annuity is the calculation of the constant annual cash flow that a project generates over its lifespan. The following formula is used to have it:

$C = (r \times NPV) / (1 - (1 + r)^{-n})$

Where: C = EAV; NPV = net present value; r = interest rate per period, and n = number of periods (Investopedia, s.d.)

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